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(54) **Compound Material for Protective Clothing**

(57) A material for use with protective clothing is formed of an outer layer and at least one inner heat insulating layer with the outer layer having on its inner side a mineral fibre layer and in which the inner heat insulating layer is formed as an air-permeable foam layer with active carbon particles in the pores thereof.

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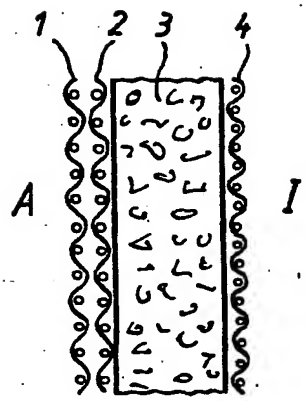

FIG. 1

SPECIFICATION

A Compound Material for Protective Clothing

The invention relates to a compound material made in layers for protective clothing to be used against heat radiation and damaging chemicals, with an outer fireproof layer and at least one inner heat-insulating layer and to a method of making this material.

For guarding the human body against the action of heat radiation there have been suggestions in the past making use of protective clothing with a very massive, that is to say furthermore heavy, outer material and on this outer material on the outside a reflecting facing material is placed, which is generally of metallic origin and as a rule is not permeable to air. The reflecting face on the outside has the purpose of turning back heat radiation and has to be guarded against burning, while the outer layer of the material under it is for stopping transmission of heat through the material. Such protective clothing is of good effect if used for only a short time and is reliable for guarding against continuous heat radiation more specially in the case of fires, tapping blast furnaces or the like. One shortcoming however is the weight and stiff properties of the material, which make it quite hard for the user of the protective clothing to move. A further short-coming is that there is no "breathing" of the material, that is to say that it does not let air through and for military uses the reflecting face of the compound material is in no way in line with the needs of camouflaging.

It is in some cases quite necessary for soldiers to take up positions in which an atomic attack of the enemy is likely. Such soldiers would make use of protective clothing at all times for guarding them, on the one hand, against heat radiation and on the other hand for making certain that no radioactive dust or deposit is dropped on to the skin of the body. It will clear that protection against heat radiation is particularly important on taking into account that on the explosion of a tactical nuclear weapon of the order of 10 kt, as may be fired from a heavy howitzer, even at a distance of 1.5 km from the place of the explosion, will make for third degree burns on uncovered skin. So protective clothing with a resistance of 63 J cm^{-2} is needed, which in the case of a nuclear explosion of the type noted has the necessary resistance even nearer to the explosion. Naturally for the short-time exposure, produced by the second radiation maximum of a nuclear explosion, generally very much more resistance is desired; for example a resistance of 135 J $cm^{-2}s^{-1}$ may be desired.

In this respect it is specially to be taken into account that soldiers using protective clothing may have to keep the clothing on under fighting conditions, that is to say conditions in which the body is put under very great strains, without stopping, that is to say in some cases for a time of some days.

Based on this dilemma one part of the purpose of the invention is that of designing a compound material for protective clothing, which on its outer side is unreflecting and may be painted for camouflaging, and is in line with the least needs, noted earlier, with respect to resistance to heat radiation. Furtherrhore the material is to be permeable to air but however, at the same time is to have the effect of slowing down the motion of damaging materials through it.

For effecting this purpose there is the suggestion of the invention for the outer layer of the compound material to be a flameproof or fireproof textile fabric, which on its inner side has a mineral fiber layer placed on it and in that the inner layer is an air-permeable foam material, whose pores have active carbon particles in them. The outer, fireproof layer of textile fabric has the properties of a normal textile fabric, as is used as well for military clothing so that, by making a selection of the right sort of weave, a mat face may be produced and the fabric may be colored as is normal for textile fabrics. The textile fabric is supported by a mineral fiber layer, offering enough support for the textile fabric, after the action of radiation in which the textile fabric may be burned to ash; the layer made up of the two fabrics takes up the heat radiation energy, in which case the mineral wool may be strongly heated; the transmission of heat from the mineral wool is however decreased by the foam material, and the active carbon particles take up heat energy for their part. The compound material, even after the action of heat enough for burning the textile layer to ash, will keep enough mechanical strength, because the mineral fibers have a sufficient supporting effect for the foam material. At the time of action of the heat an important part of the active carbon particles placed in the foam material will be kept undamaged so that the foam material has the effect of a filter not letting through any contaminated deposit or dust.

The textile layer, the fiber layer and the foam material layer are in each case permeable to air so that long use of clothing made of the compound material of the invention is possible. Furthermore the materials used are very light in weight and, in comparison, may readily be bent so that it will not be so hard for the user to move his body as is the case with known material with a heat resistance of the same order.

Protective clothing made up of the compound material of the invention is not only to be used against the heat radiation of a nuclear explosion but generally as a way of guarding the body against powerful heating effects lasting only a short time, and against the effect of damaging chemicals.

As a textile fabric it is, in accordance with one developement of the invention, of particularly good effect to make use of a water-repellent, oil-repellent and flameproofed cotton fabric, which more specially has a weight of 80 g/m^2; such a fabric may be colored or dyed with any desired color, may be printed, for example with

camouflage patterns, and is handy in use; normal materials may be used for conditioning or impregnation. The specially good property of the material is however that the cotton is not able to be melted, that is to say it is turned into ash on the heating effect lasting long enough, without any melt having been formed which might be taken up into the substance of the compound material, something which might make for overheating at certain parts of the clothing.

Generally speaking it is possible for the mineral fibers to be put in the form of a non-woven material or batt which may then, if necessary, be joined to the textile fabric by needling, or may be felted, for stopping the mineral fiber material from coming off the textile fabric in use. However in accordance with one development of the invention it is of particularly good effect if the mineral fibers are woven into a fabric, more particularly with a weight of 40 g/m² and are then covered with the textile fabric. In this way a mineral fiber layer is produced, without making the support-function any less good, which is far thinner than normally the case and, for this reason, is light in weight and this mineral fiber layer is so joined to the textile layer by the covering operation that even on rough use the textile layer has the effect of guarding the mineral fiber fabric against damage.

In accordance with a further development of the invention the adhesive, necessary for the covering operation, is in the form of a thermoplastic material, which is made soft by the effect of heat but however does not have such a low viscosity that it might be taken up deeply into the substance of the compound material. After any burning to ash of the textile fabric layer this thermoplastic adhesive will have the effect of fixing the ash to the mineral fabric and for this reason - dependent on the colour impregnation of the textile fabric - will make certain of a coloring of the face seen of the material so that even after the effect of heat there is a camouflage coloring. Furthermore the adhesive has the effect of a support for the mineral fabric and in particular makes it less likely to be broken. In order to make this effect even better the mineral fibers of the mineral fiber fabric are bedded in the thermoplastic material so that the fibers are not only supported but furthermore guarded against damage for a long time so that they will go on having the desired function even after long times of use.

Because of the simple way in which the material is produced it is of good effect, in a further development of the invention, for the foam material to be fixed by welding or sticking to the mineral fiber layer, a duroplastic or thermosetting adhesive being of good effect in this respect. In a further development of the invention it is however likely to make for a better quality of the clothing if the foam material is fixed by sewing on the fabric layers; in this design it is possible to make certain that after the effect of heat the mineral fibers are kept fixed to the foam material strongly for supporting it, even if the effect of the heat makes for a melting of the foam material for a short time in the parts near the mineral fibers. It is however best to make use of a heatproof sewing thread, more particularly one made up of mineral fibers.

In accordance with a further development of the invention the inner face of the foam material is covered with woven or knitted fabric of fibers for stopping any damage of the foam material, stopping any dropping out of the active carbon particles and furthermore making for a facing layer which is of the right type for coming into contact with the skin of the user. In accordance with a further development of the invention these fibers are polyamide fibers, which are fixed to the foam material by welding or sticking. Such fibers not have the necessary chemical resistance and mechanical strength but it is furthermore possible to make a fine but not felting fabric, which is porous enough and which on the other hand keeps back active carbon particles, while on the other hand not becoming stopped up by a felting effect or the like.

Generally speaking it is possible to make use of a foam material with active carbon powder in it for which an earlier suggestion has been made, for example in the German specification (Offenlegungsschrift) 2,400,827. In a further development of the invention it is however of particularly good effect for the active carbon particles to be, at least partly, in the form of round (or spherical) porous adsorber grains. The structure and the way of making such adsorber grains is detailed in full in the German patent application 28 04 154.5, to which attention is to be given and which may be said to be a part of the account given in the present application. These adsorber grains have an outer face which, by way of comparison, is generally sealed but however all in all they are porous so that this face able to be used for adsorbing materials, is very great in size. Such adsorber grains are if anything, only damaged on the outer face in the case of high temperature heating effects lasting a short time and generally, after the heating effect, there will be enough pieces of the adsorber grains still in existence for making certain of a cleaning effect and one taking up poisons and making them of no effect.

In accordance with a further developement of the invention of good effect the foam material is polyurethane foam material, which is resistant enough to damaging substances and is in line with the needs of use of the material.

On making the compound material of the invention the use of a filter material is of good effect, of which an account has been given in the patent application 28 04 154.5.

As has been made clear by tests, a 2 mm thick foam material layer is much less in the way of motion of the user in protective clothing than seemed likely, because the polyurethane foam material used is in fact very light in weight and soft, that is to say readily bent.

The compound material of the invention may,

in a further development of the invention, more particularly be made using mineral fibers of which a little less than one half is silicon dioxide and a little less than one quarter is calcium oxide, the fibers furthermore been made up of sodium oxide, boron trioxide and aluminium trioxide.

In accordance with a further form of the invention these materials are mixed in a grinding operation, melted for 12 hours at +1400°C, then worked or kneaded for 12 hours at +1200°C. Then the material produced is slowly cooled, granulated in a solid condition, melted again and pulled out to filaments by nozzles, that is to say extrusion-drawn. Such a fabric is particularly good for meeting the requirements of strength and resistance to heat.

For covering such a fabric with the textile fabric an adhesive is used which is made by polyaddition of triisocyanates and divalent alcohols or other compounds with hydroxyl groups; the polyurethane produced is dissolved in a ketone and mixed with the relation of 9 to 1 with a generally marketed saturated bromine solution of the right type. While agitation is taking place for a time lasting 6 hours and sealed off from the air 5 g (dry weight) of magnesium powder are mixed in slowly for each 100 g (wet weight) of polyurethane.

In accordance with a further form of the invention an amount of about 25 g of this plastics adhesive are run on to each square meter of the mineral fiber fabric and then freed of solvent in an air current at 180°C. Then the coated mineral fiber fabric is put on the textile fabric in a covering or coating apparatus and pressed at pressures of about 300 kg/cm² (measured between pressing rollers). Then, in a further form of the invention, the material produced is powdered with sodium silicate and rolled up in lengths of 2000 to 3000 meters. The material is to be kept in the roll for about 72 hours for complete polymerizing of the thermosetting reson. The outcome is a material with a specially high resistance.

Generally speaking it is possible for parts of protective clothing as for example boots or the like to be produced as moldings; it is however best for the material to be made in the form of lengths, which are then processed to make the desired pieces of clothing. On making into clothing, something which may take place by sewing, it is of particularly good effect if the textile fabric, covered with the mineral fiber fabric, undergoes sewing with mineral fiber threads not running through the whole thickness of the compound material; the inner side may be in addition fixed by sewing with other threads as needed.

It is lastly to be pointed out that the compound material of the invention is particularly good for use in clothing, though however it is not limited to this use and in fact it is possible for the material to be used for making bags, for example for storing apparatus likely to be damaged by heat as for example portable transceivers, detonators or the like. It is furthermore possible for the material to be used for making tarpaulins, sleeping sacks, groundsheets and the like for military positions, for providing a certain degree of protection against the effect of nuclear weapons, the invention covering all these structures made of the material of the invention and - as far as an account is given of it - furthermore covering the making of such structures.

The drawing is a diagram in the form of a cross-section through a length or a piece of clothing of the compound material of the invention. On the outer side A there is a textile layer 1 of cotton fabric, on which a mineral fiber fabric 2 is fixed by a thermoplastic polyurethane adhesive. Next to the mineral fiber fabric there is a polyurethane foam layer 3, whose pores have active carbon in them. The active carbon is made up at least in part of round (or spherical) porous active carbon bodies, whose inner pores have a very great functioning face area. The face, on the inner side I of the length of compound material, of the foam material 3 is covered with a woven or knitted fabric 4 of polyamide fibers, which are fixed to the foam material 3 by sticking, that is to say adhesively, or by welding.

The materials of the drawing has enough protective effect for persons with respect to thermal pulse radiation of up to 32 $cm^{-2}s^{-1}$ or 135 J $cm^{-2}s^{-1}$.

The "breathing" property or air-permeability of the compound material of the drawing is 300 1/m² under a vacuum head of 1 cm of water, if the material is made with the preferred dimensions given in the introduction to the specification. The weight is about 150 g/m² for 1 and 2 and 250 g/m² for 3 and 4 = about 400 g/m² for the overall material.

The two outer layers 1 and 2 and the foam material layer 3 and, on the other hand, the foam and fabric layers 3 and 4 are fixed together by sewing. In this respect it is of particularly good effect for the low-price making of pieces of protective clothing, protective bags, protective coverings etc. for the separate cut parts, to be joined together by sewing, to be cut out separately or together from a length formed by the outer layers 1 and 2 and a length formed by the inner layers 3 or 3 and 4 and then joined together later on sewing together the part of the protective clothing or the like with the necessary sewing stitches. In this respect it is of specially good effect, if necessary, for large cut out parts to be quilted in addition.

Claims

1. A compound material made in layers for protective clothing to be used against heat radiation and damaging chemicals, with an outer fireproof layer and at least one inner heat-insulating layer, characterised in that the outer layer is a fireproof textile fabric, in that on its inner side a mineral fiber layer is placed and in that the inner layer is an air-permeable foam layer, whose pores have active carbon particles in them.

2. A compound material as claimed in claim 1,

characterised in that the textile fabric is a cotton fabric, conditioned for repelling water and oil and made resistant to burning and having, more specially, a weight of 80 g/m².

3. A compound material as claimed in claim 1 or claim 2, characterised in that the textile fabric is covered with a fabric of the mineral fibers, more specially with a weight of 40 g/m².

4. A compound material as claimed in claim 3, characterised by a covering inbetween layer between the textile fabric and the mineral fiber fabric of thermoplastic plastics adhesive.

5. A compound material as claimed in claim 4, characterised in that the mineral fiber fabric is bedded in the thermoplastic plastics adhesive.

6. A compound material as claimed in anyone of claims 1—5, characterised in that the foam material is welded on to or adhesively joined with the mineral fiber layer.

7. A compound material as claimed in anyone of claims 1—5, characterised in that the foam material is fixed by sewing on the outer layers.

8. A compound material as claimed in anyone of claims 1—7, characterised in that the inner face of the foam material is covered with a woven or knitted fabric of fibers.

9. A compound material as claimed in claim 8, characterised in that the fibers are polyamide fibers joined by welding or adhesively with the foam layer.

10. A compound material as claimed in anyone of claims 1—9, characterised in that the active carbon particles are formed at least partly as ball-like, porous adsorbtion grains.

11. A compound material as claimed in anyone of claims 1—10, characterised in that the foam material is a polyurethane foam material and is more specially 2 mm thick.

12. A compound material as claimed in anyone of claims 1—11, characterised in that the mineral fibers have the analysis by parts by weight:

54.5	silicon dioxide (SiO_2)
0.5	sodium oxide (Na_2O),
8.5	boron trioxide (B_2O_3),
14.5	aluminium trioxide (Al_2O_3), and
22	calcium oxide (CaO).

13. A method of making a compound material as claimed in claim 12, characterised in that the materials are mixed in a grinding operation, melted for 12 hours at 1400°C, worked or kneaded for 12 hours at 1200°C, slowly cooled down, made into grains in a solid condition, melted again and made into filaments in a pull-extrusion method.

14. A method for making a compound material as claimed in anyone of claims 1—12, and as is claimed in claim 13, characterised in that for covering a normally produced thermoplastic polyurethane is used, and however the polyurethane is dissolved in the right sort of solvent before use, more particularly in a ketone, is conditioned with a saturated bromine solution and in an agitating operation, lasting a number of hours, is mixed, while sealed off from the air, with an amount, equal to about 5% of the wet weight of the polyurethane, of very finely ground magnesium powder.

15 A method as claimed in claim 14, characterised in that the plastics adhesive at a dry weight of about 25 g/m² is run on to the mineral fiber fabric and is then air-dried, more specially at 180°C, and then the cotton fabric is rolled on with a pressure of about 300 kg/cm².

16. A method as claimed in claim 15, characterised in that right after the rolling on sodium silicate powder is dusted on to at least one face.

17. A method as claimed in claim 16, characterised in that the covered fabric of cotton and mineral fiber fabric is rolled up tightly and is kept in the rolled-up condition for about 72 hours for polymerizing of the plastics adhesive.

18. A method for making a compound material as claimed in anyone of claims 1—12, and as claimed in anyone of claims 13—17, characterised in that the outer layers are placed loosely on the foam material and it is only after making into clothing that they are fixed together by sewing at the seams of the separate cut parts.

19. A compound material as claimed in claim 1 substantially as described above.

20. A method as claimed in claim 13 substantially as described above.

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